STUDIES ON THE NATURE OF CERTAIN SYMPTOMS ASSOCIATED WITH CARDIOVASCULAR DISORDERS *

GEORGE A. WOLF, JR., M.D.,** AND HAROLD G. WOLFF, M.D.**

Two groups of individuals who cannot meet the demands of their life situations may develop symptoms of circulatory disorder. The one has symptoms resulting primarily from structural disease of the heart and circulatory failure. The other and larger group includes those patients who have symptoms of circulatory disorder primarily for other reasons, regardless of whether they do or do not have structural heart disease. The purpose of this study is the analysis of the symptoms referable to the cardiovascular and respiratory systems occurring in patients with and without heart disease but not caused by valvular or myocardial damage or congestive heart failure.

The undamaged heart has a capacity to meet the demands of strenuous efforts far beyond those of the usual daily activities. The ability to tolerate strenuous effort cannot be interpreted solely as an expression of myocardial effectiveness but rather as a manifestation of the total circulatory function, which in turn is intimately related to the life situation of the individual, his attitudes toward the latter and his feelings.

The following study has been focused upon the reactions of a small group of individuals to a variety of life situations, with special reference to cardiovascular and respiratory functions. Emphasis was placed upon the reactions to persistent low-grade stresses and strains which are a part of "every day" living and which constitute the core of the bedside problem, rather than upon the well-known responses to major life crises. It has been possible by a day to day study over a period of almost a year to obtain such data. Attempts were made to ascertain to what extent efficiency of the cardiovascular and respiratory systems was impaired during certain life situations, what the identifiable emotional responses were and how these various reactions bear upon symptoms and disease.

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** From the Departments of Medicine (Neurology) and Psychiatry, Cornell University Medical College and The New York Hospital.

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METHOD

Cardiac Output: A ballistocardiograph was constructed (53). The design incorporated features from the instrument used by Nickerson and Curtis (47) and Meneely (44). Essentially it represented a high frequency and moderately but not critically damped bed. Calibrations were made before each experiment, and calculations employed the wave area formula of Starr (53). Cournand *et al.* (16) have shown that ballistocardiographic values are generally lower by a constant amount than results of determinations by the Fick principle. To avoid the controversial issue concerning absolute output (58), the results in these experiments are expressed in percentage change over the daily resting level. The cardiac output measurements are in accord with the figures obtained by Starr (53). Nickerson and Curtis (47) have indicated that values obtained on the ballistocardiograph vary according to the manner in which the record is taken. In these experiments attention was focused upon the change following exercise each day rather than on the daily resting levels. This method causes no discomfort or pain since it avoids such procedures as arterial puncture or auricular catheterization.

Respiration: Recordings were made with a Benedict Roth type of spirometer equipped with a fan to improve gas circulation. The reservoir was filled with oxygen and the contents of the bell were tested frequently for the presence of carbon dioxide. The soda lime container was changed after thirty-five experiments. Measurements of oxygen consumption, minute ventilation, tidal volume, vital capacity, mid-position of the chest, and utilization coefficient were made.

GENERAL PLAN OF THE EXPERIMENTS

Two healthy, trained observers were studied over a ten months' period at approximately the same time each day. The subjects were observed in the middle of their working day, two hours after the ingestion of food. It was desired to observe their responses to the experimental situation under those circumstances which most closely approximated every day life situations. They were therefore not under basal conditions. The subject rested five minutes on the ballistocardiograph bed and, sub-

sequently, resting determinations of the pulse, blood pressure, ballistocardiogram, including calibration deflection, and a two-minute record of respiration were made. The subject then got up from the bed and ascended and descended two 9 inch steps a fixed number of times during a minute and a half. The number of ascents and descents was ten more than the number indicated by Master and Oppenheimer (41) for the given sex, age and weight. This amount of work in these two subjects resulted in a blood pressure rise which usually returned to the resting level after two minutes. Immediately after exercise the subject returned to the ballistocardiograph bed, and thirty seconds after exercise a ballistocardiogram was taken. At one, two and three minutes, pulse and blood pressure were recorded. At three minutes another ballistocardiogram was taken, and immediately thereafter a six minute spirometer tracing was made. Vital capacity was obtained during the last minute of this period. Ten minutes after the cessation of exercise the final ballistocardiogram, pulse and blood pressure were recorded. The day's events up to the moment were then discussed with the subject as follows: The recent use of stimulants, such as coffee, alcohol and tobacco, the length and character of the previous night's sleep, the use of medications, and the nature of physical exertion since the previous day were noted. The subject then attempted to estimate his relative energy, effectiveness and spirits. The events of the previous day and evening, the activities of the morning and the prospects for the remainder of the day were discussed. The mood, preoccupations, dreams, and behavior were described. Events bearing upon the dominant affect were noted. The operator's description of the subject was also recorded. Thus the usual methods of psychological investigation were utilized, including catamnistic and biographic data, free association, dream analysis, and description of behavior. The clinical details of minor illnesses occurring in the course of the experiment were noted. Thus a relatively precise and detailed picture of the individual in his environment and his reactions were recorded.

Also, a series of experiments were made on selected patients who, exhibiting the symptoms under consideration, were less systematically investigated. Observations of the pulse, blood pressure, ballistocardiogram, and respiration were made following exercise in the manner described in the first series, except that recordings were not made daily. Also, observations were made during interviews focused upon important life experiences. The exact procedures will be considered when the results are described.

DESCRIPTION OF SUBJECT 1

The subject was a 46-year-old physician, married, and the father of a 4-year-old child. He was a member of the university faculty and divided his energies among teaching, care of patients and investigation. He was of a linear body type, quick moving, restless, active, and moderately athletic. His health was excellent; he had had only minor illnesses and was intolerant of shortcomings in his energy. There had been no cardiovascular symptoms, and with the exception of rare headaches there were no bodily complaints. He was talkative, enjoyed badinage and humor, and smiled and laughed a good deal. He worked hard and drove himself toward his goals. His interests were narrow although his curiosity was readily aroused in a superficial way on many topics. His daily program was ordered. The subject was relatively inelastic and dealt brusquely with opposition. He resented being "pushed," and when so pressed he became irascible, aggressive and hostile. He arbitrarily rejected institutional or personal efforts to modify his arrangements.

His security was derived from two sources: (1) the affection and esteem of his wife and child, the stability of his home life and the emotional support afforded by those associated with him in his family and work; (2) the fulfillment of his aspirations in his work. He was dedicated to his work and was focused upon creative effort both in himself and in others. He was indifferent about popularity and scorned those who pursued it. He was extremely critical. Contempt was readily aroused by unwitting or deliberate pretense, deceit or self interest, especially when they involved esthetic or creative issues.

He was economically secure and had little interest in further possessions. He was extremely sensitive to assaults which threatened his values or indicated lack of backing or support by those associated with him. As regards these basic values, there was no division between those associated with him as fellow workers or as friends or family. When through pressure of circumstances or through blunt assault by those about him, his creative and esthetic values were threatened, vigorous conflict ensued. Often he was able to identify the elements in the conflict. These were associated with periods of mounting resentment and tension which ultimately ended in feelings of frustration, discouragement, dejection, feelings of not being supported, and sometimes frank though short-lived depression. Also, being pressed into patterns other than his usual—new places, travel, crowds, unfamiliar, unsympathetic

persons, committee meetings, boring situations—was associated with tension states and poor sleep. In brief, interference with the pursuit of his aims was followed by a mood colored by resentment, disdain and anger, with tension as the conspicuous feature.

DESCRIPTION OF SUBJECT 2

The subject was a 42-year-old unmarried woman who had worked for twenty-one years as an investigator. She was an enthusiastic, warm-hearted person. She was insecure and frustrated in that she put a value on approval which she could seldom win because of the fear of being hurt by criticism. She had done well in school, always standing at the top of her classes, but her subsequent performance in life had fallen short of standards set for her. She liked to work hard and had a better than average amount of energy. She was easily stirred to resentment and sometimes anger, but such emotional states were short-lived. She occasionally had short periods of depression. These were characterized by feelings of guilt and worthlessness and usually precipitated by situations which she considered unjust and which she felt were incapable of resolution. During such periods she became irritable, lost sleep and became fatigued easily. Such episodes seldom lasted more than two or three days, and for the most part her mood was cheerful and her spirits high. She had three security props which were essential to her. These included conviction of health and energy, loyalty and approval of friends, and dedication to her work. Her personality was characterized by the fact that she had strong convictions about responsibility towards her work and equally strong feelings of loyalty towards her family and friends. She was tireless when her work was approved, but was deeply hurt and exhaustible when her efforts were not recognized or approved. She rejected any intimation of weakness in herself.

A. DYSPNEA DUE TO DISTURBANCE IN VENTILATORY FUNCTION

Increase in the tidal volume sufficiently great to cause a subject to become aware of the act of breathing may give rise to one important variety of dyspnea. Increase in tidal volume may be brought about by such means as diminished oxygen capacity of the blood (anemia), impairment in alveolar oxygen transport in the lungs, increased oxygen demand in the tissues, acidosis, and obstruction in the air passage. In the course of observations upon the respiratory function of patients and normal individuals it became evident that increase in the tidal volume and minute ventilation occurred in the setting of adverse life situations and associated emotional responses.

1. Dyspnea and hyperventilation associated with sustained conflict, anxiety, humiliation, frustration, and anger.

Subject 1, some months before the following observation, had been invited to address a large lay audience on the subject of his studies. As inducement he was sent a provisional program of speakers which included his name among a group of well-known and able workers. The subject was long undecided about giving the lecture but finally concluded that the effort would be worth making because of his interest in public health and because of the representative nature of the group. Subsequently, certain phases of his investigative work became confidential because it was being done under government contract. It was necessary to alter the content of the lecture, and the decision as to what could be told became a problem and served to make the lecture a source of conflict. The subject approached the lecture with the feeling that he had made a mistake in deciding to take part in the program. In spite of his misgivings he resolved his conflict in part by deciding that what he had to say was of importance to his audience and that because others on the program had sacrificed time and effort in participating, it was his duty to conform. On the day of November 14, 1944, and preceding the lecture, the subject experienced anxiety, urinary frequency, sweating, and cold hands. The pulse, blood pressure and cardiac output were elevated markedly after exercise. The respiratory response was most unusual in that the subject was obviously dyspneic for a longer period after the cessation of exercise than on other days. The ventilation rate was three times the usual levels after the same amount of exercise. This difference was not noted in the oxygen consumption. The subject proceeded to the auditorium. It soon became apparent that arrangements had been poorly made. The program was delayed an hour in starting, and the whole atmosphere was one of casualness and poor organization; speaking facilities were inadequate. The audience was unresponsive and essentially uninterested in the content of the symposium. The twenty-four hours after the speech were characterized by anger, resentment and the feeling that he had been duped into participating in a program which was on the whole a waste of time. He was humiliated, angry and frustrated. The day after the lecture his pulse rate, blood pressure and cardiac

output again failed to return to the resting levels by two minutes after exercise. The respiratory changes were much less marked. The second day after the lecture the subject regarded the incident with humor, and the functions returned to their usual state (fig. 1).

Comment: These experiments indicate that the efficiency of the organism as evidenced in cardiovascular function was impaired (*i.e.*, the work of the heart was increased) under circumstances of conflict which resulted in reactions of anger, frustration, humiliation, and anxiety. Respiratory in-

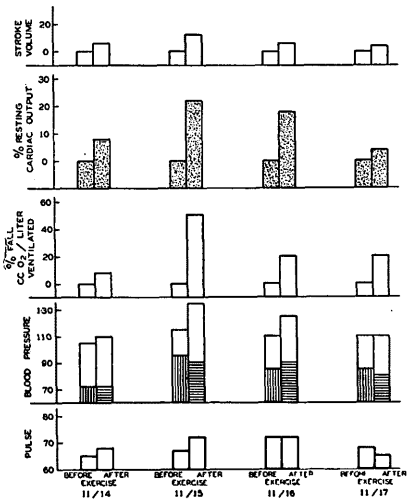

FIG. 1. Dyspnea and palpitation after exercise caused by hyperventilation and increased cardiac output in association with anxiety, frustration and anger. The per cent fall of ccs. of oxygen per liter ventilated is equivalent to per cent increase in air ventilated per cc. of oxygen utilized.

efficiency was apparent (*i.e.*, oxygen utilization was diminished) and was shown to be dependent upon impairment of the ventilatory rather than the respiratory mechanism of respiration (17). Thomas (63) has shown that in patients with so-called soldier's heart, the oxygen utilization is impaired in a similar fashion.

2. *Dyspnea and hyperventilation associated with the emotional response to an acute illness.*

On October 18, 1944, following an upper respiratory infection, subject 2 complained of fullness in the right ear. That night she awoke from sleep with right otalgia and otorrhea. The otologist advised a myringotomy and admission to the hospital. The situation then changed in that the subject became apprehensive about the operation. The factors in this apprehension were: 1) frankly expressed fear of the operation because of the possible serious complications of a myringotomy; 2) a preoccupation with the complications of otitis media; 3) her feeling of personal insecurity and humiliation in losing her usual good health ("I felt caught . . . . that the situation was out of my hands"); 4) she wanted to remain at her job, fearing the unvoiced disapproval of her employer. Bed rest was maintained during a four-day period and sulfadiazine was given. Fever and leucocytosis were absent. As her physical state rapidly improved, her conflicts became more marked because she desired to return to work and yet could not obtain her

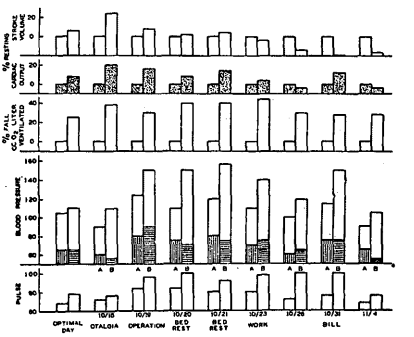

FIG. 2. Hyperventilation and circulatory responses to exercise during a period of acute illness and emotional stress.

physician's approval. His misgivings also created further doubt about the complications of her illness if she left the hospital. Just prior to her discharge from the hospital she wept for about an hour. She then returned to work and stopped her medication but remained apprehensive about her physical state. At the end of a week she had no complaints. Observations were made during this entire period and are illustrated in figure 2. Prior to the operation, during the period of hospitalization and after the subject returned to work, the cardiovascular responses were characterized by high levels of the pulse, blood pressure and cardiac output after exercise, in contrast to the responses on optimal days. The day after the operation the subject complained that the given amount of exercise "seemed to be more difficult" than usual, and respiratory tracings revealed a greater minute ventilation after exercise than was observed on optimal days (see fig. 3).

Oxygen consumption was not similarly affected. The cardiovascular and respiratory functions approached optimal levels during the week following the illness. On October 31 the subject received a statement of her hospitalization costs. Attention is called to the fact that the responses of the cardiorespiratory functions after exercise closely resembled those seen during the height of her illness.

Comment: The course of events described above is common during minor illness and represents, as in this subject, the effect of bacterial invasion plus reactions associated with fear, anxiety, frustration, and resentment. Thus, on October 18, when the effects of bacterial invasion (*i.e.*, prior to drainage of pus) were probably approaching their maximum for the illness, the cardiorespiratory derangements were not as striking as on October 21, when the effects of the invasion were becoming minimal.

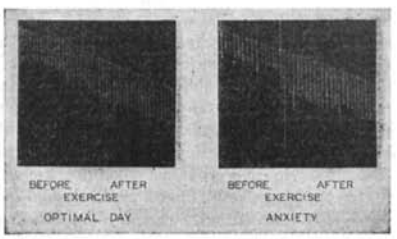

FIG. 3. Spirograms showing hyperventilation present four minutes after exercise associated with dyspnea on a day when anxiety was experienced prior to a minor operation.

However, as the improvement continued, her conflict became more and more intense, associated with clearly evident circulatory derangements and general debility. To support the concept that most of the defects were not dependent upon bacterial action, bed rest or chemotherapy stands the performance before and upon receiving the bill of costs for her hospitalization. Here, with recurring resentment, the circulatory and respiratory derangements closely resembled those seen in the middle of the illness.

The above-described cardiorespiratory changes may be relevant to the dyspnea commonly occurring in convalescence in addition to such symptoms as weakness, palpitation, easy fatigability, dizzy spells, and fainting (see section D). They may also have some bearing on the frequent occurrence of cardiovascular neuroses following minor illnesses.

3. *Nocturnal dyspnea simulated by hyperventilation during periods of suppressed rage.*

A 34-year-old woman, complaining of attacks of nocturnal dyspnea, with essential hypertension without clinical evidence of irreversible vascular disease, was interviewed while lying on the ballistocardiograph bed. Records of respiration, pulse, blood pressure, and cardiac output were taken before, at intervals during and after the interview. The patient related and discussed those aspects of her life situation which were considered most relevant. She was told to talk freely and not hesitate to display her feelings. Her statements were recorded and chronologically related to the physiological observations. The interview itself represented a stress-producing situation. The resting observations before exercise the day before and just before the interview were identical. During the interview the patient was aware of and complained of feelings of isolation and loneliness because of her husband's absence. (He was in the Army and overseas.) She described working for a perfectionistic employer under work conditions which all recognized as difficult and which made "perfect work" impossible. Nevertheless, her employer, during his tension states, loudly disapproved of the patient's performance; and the latter, herself a perfectionist, was deeply hurt and enraged. During her married life and before her husband's departure she was able at the end of the working day to voice her anger and regain her personal dignity through her husband's sympathy and support. But after his departure and because of her stand-off, aloof manner, which precluded confidential discussion with friends, her suppressed anger turned to rage and her tension mounted. At the time of the interview she was aware only of tension but told about obsessive and morbid fears. The fear of poisoning from the gas jet of her refrigerator caused her to turn it off at night. More lately she had feared that she might hurt someone or herself. She also had murderous dreams.

Figure 4 shows the changes in cardiovascular and respiratory function which occurred during the interview with this patient. The blood pressure and cardiac output were seen to be significantly elevated during the interview, and they returned to resting levels after reassurance and a hopeful formulation. Respiratory tracings done before and after the interview demonstrated that as a result of the interview the minute ventilation doubled and the utilization coefficient halved, without significant alteration in the oxygen consumption. The minimum oxygen consumption attendant upon respiratory effort was not great enough to be detected by the method used. The effect of the interview on respiration was similar to the effect of exercise, although the patient had not moved from the bed (see fig. 5).

Comment: The effects on blood pressure, cardiac output and respiration were as great or greater and more prolonged during recall of disturbing life situations than following exercise, which was tolerated well, according to the standards of the Master Two Step Test (41). The patient complained of awakening at night with a sensation of constriction

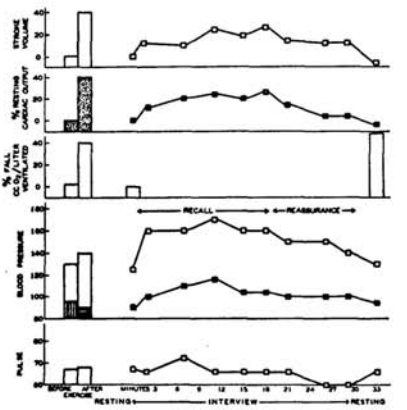

FIG. 4. Palpitation and dyspnea caused by increased stroke volume, hyperventilation and a pressor response associated with suppressed rage.

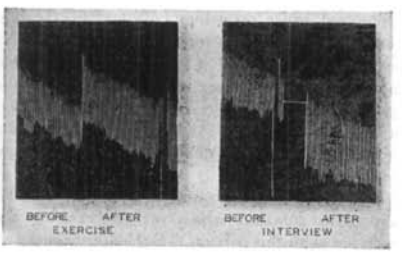

FIG. 5. Spirograms showing hyperventilation before and after exercise and before and after a period of suppressed rage.

in the throat, palpitation and shortness of breath. These symptoms stemmed from an increased stroke volume (section B) and increased respiratory ventilation. The patient did not have paroxysmal nocturnal dyspnea associated with failure of the myocardium, but she nonetheless was shown to have under circumstances of stress increased minute ventilation, increased stroke volume and increased cardiac output. The patient had no symptoms of hypertension, but after three days in the hospital not "on bed rest" her blood pressure fell from 180/120 to 130/90. The removal of the patient from her environment, which was stress producing, was probably a major factor in this change. It is true that her activity in the hospital was less than at her work and at home. It should be noted, however, that after three days in the hospital, during which she was appreciably reassured and had restful nights, her systolic blood pressure rose only 10 mm. after exercise. The ventilatory response to stress-producing situations was the cause of dyspnea in this patient.

4. Dyspnea caused by hyperventilation and congestive heart failure in an anxious female with hypertensive cardiovascular disease.

A 50-year-old female with hypertension and a history of a cerebral vascular accident complained of cough. The patient was a tense, hyperactive, independent widow, who was lonely and did not want to burden her children. She thus assumed an active social life which included moderate drinking, long walks, late hours, and ocean swimming. Her cardiorespiratory symptoms developed in this setting. Examination revealed a restless female with obvious dyspnea, a dry cough and orthopnea. The neck veins were engorged. The blood pressure was 220/120, pulse 95, respiration 28. Percussion and auscultation revealed no signs of pulmonary engorgement. The heart was enlarged and the precordium heaved with each cardiac systole. Gallop rhythm was present, and a pulsus alternans was noted. Slight ankle edema was observed; the liver was not enlarged. The patient refused to go to bed and followed diet and fluid instructions inadequately. She was "digitalized" in forty-eight hours to the point of nausea and vomiting. At that time, although she still complained of dyspnea, examination revealed only sighing respirations at a rate of 16. The cough was absent. The lungs were clear, and the heart rate was 60/min., with no gallop rhythm or pulsus alternans. Ankle edema had disappeared. The patient stated that she had noted for several years that when she was tense or anxious she would have a feeling of suffocation and would have to sigh to obtain a deep, satisfying breath, even at rest.

The dyspnea which persisted following "digitalization" was of this order. When examined during congestive heart failure the patient was more concerned with the occasional cough than with the persistent shortness of breath, although she realized in retrospect that her dyspnea before "digitalization" was more than that experienced by her during

periods of stress. Her voluntary statement after "digitalization" was, "I always breathe deeply when I get nervous. The cough was what bothered me. The shortness of breath is better now (sighing). I always have this when I'm nervous."

Comment: This patient had two types of dyspnea which merged into one another. One was associated with pulmonary vascular engorgement and was reduced by digitalis, and the other was associated with impairment of the ventilatory mechanism of respiration in response to her disturbing life situation. The effect of morphine and reassurance on patients with acute pulmonary edema suggests that the above two or more mechanisms play a rôle in the production of dyspnea in many patients.

General Consideration Concerning Dyspnea

Christie (14) has shown that the respiratory pattern of "psychoneurotic persons" differs strikingly from that of the average relaxed individual. Finesinger (22) has demonstrated that "unpleasant thoughts" are associated with increased depth and rate of respiration. The mechanisms by which hyperventilation occurs under these circumstances is in doubt, but some data are available.

1. The hyperventilation observed under these circumstances is probably not the result of an increased CO_2 content of the blood. Indeed, Lewis (36), and Soley and Shock (52) have demonstrated alkalosis in patients with neurocirculatory asthenia who are hyperventilating, the former resulting from the loss of CO_2.

2. Since the vital capacity of normal individuals remained uniform from day to day even in association with unusual emotional reactions, and since study by us of the return of the overdistended lung to the resting expiratory level from day to day revealed no evidence of variations in parenchymal lung engorgement in normal persons, it is inferred that parenchymal engorgement of the lung is not a factor in the production of hyperventilation in these studies (15).

3. The facts (a) that the dyspnea noted in the above experiments was associated with untoward emotional states and evidence of autonomic activity (tachycardia, sweating and flushing), and (b) that strong visual, auditory and noxious stimuli can give rise to deep breathing and gasping demonstrate that the production of hyperventilation, or at least its instigation, involves nervous mechanisms. Further evidence that neural mechanisms are involved is afforded by the observation of Harrison (32), who described the sudden onset of dyspnea in patients with heart failure, following single induced coughs. He has also been able to produce increased rate and depth of respiration in normal patients and dogs by passive movement of an extremity (33, 1). In dogs, this reflex was not abolished by interruption of blood flow from the extremity but was by denervation. Best and Taylor (10) state, "The greater pulmonary ventilation caused by muscular exercise as compared with that resulting from the inhalation of CO_2 is due, it appears, to reflexes originating in the contracting muscles and also to irradiation of impulses from the motor cortex to the respiratory center." These experiments suggest how the contractile state of skeletal muscle in posture and bodily movement associated with various emotional states may be linked with respiration. For example, if a discouraged, dejected individual listlessly approaches a task of lifting a weight or climbing stairs, the act is done so awkwardly that many more than the usual proprioceptive end organs are stimulated, and hyperventilation results. This barrage of afferent impulses may, then, directly or indirectly, exert an influence upon the respiratory center. That this is not alone the result of a greater oxygen requirement for muscles inefficiently used was demonstrated by the fact that the oxygen consumption was not increased in proportion to the increased ventilation in these experiments.

4. Increased oxygen requirement in association with disturbing emotions may act indirectly in the production of dyspnea. Thus, Ziegler and Levine (73) have shown that unpleasant recollections may cause a 25 per cent rise over the basal metabolic rate. Benedict (9) and Segal *et al.* (50) have also observed an increase in oxygen consumption under analogous circumstances. However, in the present experiments, the oxygen consumption was unaltered when the ventilation increased, which makes it unlikely that increased metabolism was significant in the production of dyspnea.

5. Faulkner (21) observed in a man being bronchoscoped that suggestions that engendered feelings of insecurity caused the lumen of the bronchi to become smaller in diameter. It is conceivable that such a mechanism could operate in the above discussed experiments of this study. However, since expiration was not prolonged despite an increase in tidal volume, it is improbable that the mechanism described by Faulkner was involved in the dyspnea observed.

B. PALPITATION

Palpitation may constitute the only or most troublesome symptom of patients with seriously damaged hearts or of patients with cardiac neuroses.

There would seem to be little doubt that the tissues surrounding the normal heart are being stimulated at all times. Each contraction of the heart muscle converts energy into several forms: it gives acceleration to the mass of blood in the ventricles, which sets up a mechanical recoil which can be measured by the ballistocardiograph (53); the mechanical energy from this complex force and other sources of mechanical energy give rise to vibrations in part detected as sound, as demonstrated by the stethograph recordings or the total vibrations measured by the vibrocardiogram (35). Tissue adjacent to the heart may be stimulated by these vibrations, or actual displacement of the tissues may be produced by the movement of the heart itself. But few of the effects of such stimulation reach consciousness.

Palpitation may be defined as sensations, usually painless, experienced in the chest or over the heart and presumably arising from the heart or its adjacent tissues. There is no evidence to suggest that the sensory threshold in the periphery is lowered during the period of palpitation. Changes in the intensity or frequency of stimuli caused by the beat of the heart may be associated with (a) increased stroke volume; (b) displacement of the heart or tissues around it so that tissues ordinarily not stimulated by the beating heart are in a position to be stimulated; (c) occurrence of a beat out of phase with preceding and succeeding beats; and (d) rapid beating of the heart.

It has been shown (5, 13) that when the fibrous pericardium adjacent to the diaphragm is stimulated, the subject experiences sensations of touch and pressure and pain. Capps (13) has "tripped" the apex of the heart with a wire and induced feelings of distress and apprehension but no pain.

There are a number of disorders of the heart in which palpitation is common, and probably stems from one or more of the above-mentioned mechanisms. Thus, although auricular fibrillation is associated with a reduced cardiac output (61), the stroke volume is extremely variable as evidenced by the pulse deficit. After a "run of beats" with a small stroke volume, a beat of large stroke volume may produce a sensation arising from the region of the heart. The rapid rate or the occurrence of beats out of phase may be responsible for the palpitation in this disorder.

Premature contractions may give rise to palpitation because the beats occur out of phase (26).

Awareness of the heart beat may occur with change of position so that the apical impulse impinges against the chest wall. When a person with a thin chest wall lies on his left anterior chest in bed, he becomes aware of his heart beat. The apex impulse against clothes may give rise to cutaneous touch sensation sometimes causing palpitation. Marked hypertrophy of the heart may also cause movement of the structures of the chest wall to produce palpitation.

It is obvious that the presence of these disorders is not the sole factor in the production of the symptom, as patients demonstrating these defects, such as auricular fibrillation, incomplete heart block or tachycardia, may not have palpitation. Although in each case an apparently adequate stimulus is present, it does not necessarily give rise to sensation. Perhaps conditioning and attitude are concerned with the perception and reactions to these stimuli. Situations which exert such conditioning effects may also serve to effect changes in the pulse rate and stroke volume. Whitehorn *et al.* (70) have demonstrated that the pulse rate may change in response to the recall of, as well as to the presence of, disturbing situations. The following experiments show that an increase in the stroke volume may be associated with palpitation in a setting of conflict and such feelings as anxiety, fear, anger, resentment, aggression, and tension.

1. Palpitation associated with increased stroke volume during periods of suppressed rage.

A 33-year-old colored female (see section A, figs. 4 and 5) complained of nocturnal attacks of dyspnea and palpitation. She was found to have hypertension with no evidence of heart disease or irreversible vascular disease. During an interview concerning her life situation, under the experimental conditions, she recalled events producing fear and anxiety. Among other responses to the recall of these stress circumstances, the stroke volume rose about 20 per cent over the resting level and fell on reassurance to the resting level. It became evident that she dwelled upon her difficulties when alone at night, and the recall of these resulted in increased stroke volume and palpitations, conditioned by the fear of death and suicidal thoughts, and while dwelling upon the insolubility of her situation increased stroke volume was associated with appreciation of stimuli arising in the tissues about the heart, and the symptom of palpitation occurred.

2. Palpitation associated with increased stroke volume during a period of conflict.

Subject 1 was in the state of anxiety and tension prior to giving a lecture (see section A, fig. 1). Exercise was followed by palpitation or awareness of a forceful heart beat. Measurements showed, among other things, that the stroke volume was elevated 15 per cent above the resting level three

minutes after exercise. Figure 11 shows that the intensity of vibrations in the first heart sound can be correlated with the amplitude of the stroke volume in this individual. Therefore, exercise in the presence of a stress-producing situation results in a stroke volume which remains at a higher level than usual after exercise and is associated with more intense heart sounds, which could provide an adequate stimulus to the production of palpitation.

3. Palpitation associated with increased stroke volume and suppressed resentment and anger: Dissociation of blood pressure and cardiac output response to exercise.

Following a period of sustained effort with frustration, on October 10, 1944, subject 1 was exhausted and tense. The previous night he had been wakeful, and what sleep he had was colored by dreams with murderous content. As a result of this bad night he had decided to slow down and assume fewer responsibilities for a brief period. As a matter of fact, however, circumstances so shaped themselves that such relaxation was impossible, and he was obliged to assume more than the usual workaday burden. Under these circumstances of conflict he became resentful and tense. He felt unsupported, vulnerable and prostrated, and figuratively snarled in self-protection. The picture was one of a man fighting with his back to the wall. The behavior was that of one who was simmering with resentment. (Case notes included the following descriptive comments: Underactive, cynical, smouldering resentment, prostration, snarling, grumbling, with but little talk, muttered imprecations.) The subject did not exhibit pallor, cold hands, sweating, or flushing. Figure 6 reveals that the pulse had returned to the resting level within two minutes after exercise, and the blood pressure which was low initially had also returned to the resting level. The ventilation was not unusual. Three minutes after exercise the cardiac output was still 25 per cent above the resting level, the level being maintained by an increased stroke volume.

Comment: It is of interest that the bodily reaction as far as here studied was minimal, with the exception of the cardiac output, which was still elevated three minutes after exercise, suggesting that the mood and most of the circulatory reactions were suppressed. This pattern of response appears to have a minimal component of change in the contractile state of the peripheral arterioles, although adequate cause for palpitation is exhibited in the increased stroke volume. This minimal reaction is in contrast to that which is described in the following section in which reactions are overt and hyperdynamic. Grollman (30) states that the cardiac output, increased in response to emotionally charged situations, returns to its resting level coincident with the fall of pulse and blood pressure. The above experiment shows that this is not always observed. Indeed it demonstrates a dissociation between the rate of fall of the cardiac output and systemic arterial blood pressure after exercise. Starr (57) has also observed an analogous dissociation of blood pressure and cardiac output. He has demonstrated

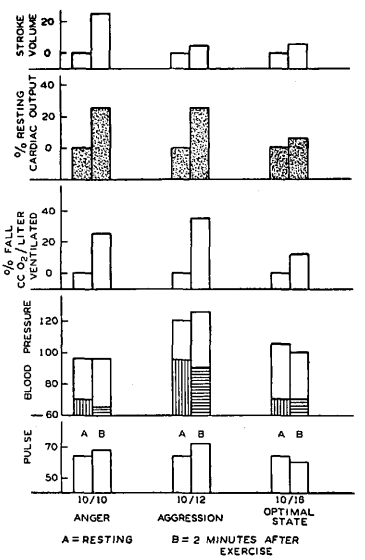

FIG. 6. Palpitation and increased stroke volume after exercise in association with anger. Note the dissociation of pulse rate, stroke volume and pressor response during different affective states.

that the blood pressure rise in some patients with neurocirculatory asthenia is caused by an increase in the cardiac output, while the rise in blood pressure in some patients with essential hypertension is the result of increased peripheral resistance. Palpitation associated with increased stroke volume may occur without alteration in other categories of cardiovascular function.

4. Palpitation and increased stroke volume in association with overt expression of anger and aggression.

After a series of contacts with a group of fellow workers, with whom various aspects of their work

was being evaluated, subject 1 gained the impression that the dominant note in the exchange was deceit, pretension and affectation. The period was culminated by discussions at a formal scientific meeting in which essentially the same content was noted. The subject was thrown into a tense, resentful, depressed, angry, hostile state. He complained of feeling isolated, alone and unsupported by his fellow workers, who were important to his security. The dominant emotional reaction was rage, outwardly manifested as irascibility. (Case notes include the following descriptive comments: Talkative, scolding, noisy, swearing, enraged, irascible, tense, overactive, gesticulating, angry looking, flaring anger resembling a temper outburst, desire to lash out in self-protection.)

The results of the experiment on October 12, 1944, are shown in figure 6. The pulse was unchanged. The resting blood pressure was higher on this day than was usual and after exercise did not return to even the pre-exercise high level. The utilization coefficient fell, and the cardiac output was elevated three minutes after exercise.

Comment: In this instance the subject's behavior was characterized by overt expressions of anger and aggression. Peripheral vascular as well as the cardiac output changes after exercise were noted. The increased stroke volume constituted an adequate stimulus for the production of palpitation.

5. Palpitation and the prolonged elevation of the cardiac output after exercise associated with tension.

Subject 1, emotionally dependent upon his wife, was significantly influenced by her state. Hence, when through the pressure of her own professional responsibilities she became preoccupied and failed to render support, the subject became resentful, aggressive and tense. It was during such a period when, on November 9, 1944, for reasons which were not identifiable, the subject was tense and anxious and became especially aware of the preoccupations of his wife. He felt unsupported and resentful, and experienced a period of dejection with tension.

The cardiorespiratory functions on November 8 and November 9, 1944, are shown in figure 7. It will be noted that the cardiac output remained elevated as long as ten minutes after exercise, even though the other functions had returned to the resting levels by two minutes.

Comment: The above commonplace incident demonstrates that palpitation may persist after exercise when other evidences of increased cardiovascular function have returned to resting levels.

6. Palpitation and increased stroke volume in association with resentment and anger.

Subject 2 received a bill, after the illness described in section A, which seemed unjustifiably large and implied a lack of appreciation for years of faithful service. Actually she considered herself an old and valued worker. The magnitude of the bill implied to her that this was not the case and that she did not hold a favored position in the eyes of the institution where she worked. She looked and acted as though angry, experienced palpitation, and the dominant affects were feelings of being injured, resentment and fear of being humiliated in front of those who felt that her prolonged hospitalization was unnecessary. The associated response of

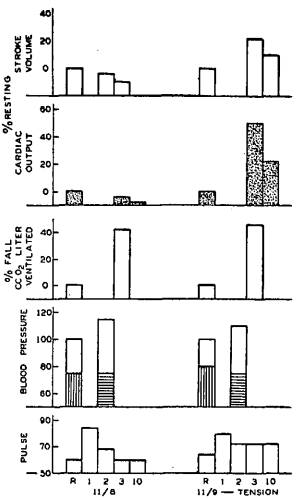

FIG. 7. Palpitation and prolonged elevation of the stroke volume after exercise during a period of tension.

the cardiovascular system included an elevation of the blood pressure, pulse and cardiac output after exercise (see fig. 2).

7. Palpitation and increased stroke volume associated with anxiety and following guilt dreams.

Subject 2, in August 1944, had committed herself to the care of an alcoholic friend. Her home situation so altered in the interim that it became manifestly impossible for her to assume this added responsibility. She therefore rejected her friend. She felt anxious and guilty in not assuming this responsibility to which she had committed herself, because her convictions about loyalty gave this decision great significance. On November 24, 1944, during the night after the decision, the patient experienced a dream which implied guilt and anxiety.

The dream was extremely vivid, well organized and consistent. The topic was about exposure and public disapproval, finger of scorn, letting someone down, and shame. "There was no escape despite much travel." The content was guilt, anxiety and attempts at self-justification. She awakened, aware of these conflicts and emotional reactions, which persisted throughout the experiment day in which the following observations were made. The resting level was not unusual, but after exercise the pulse, blood pressure, cardiac output were markedly ele-

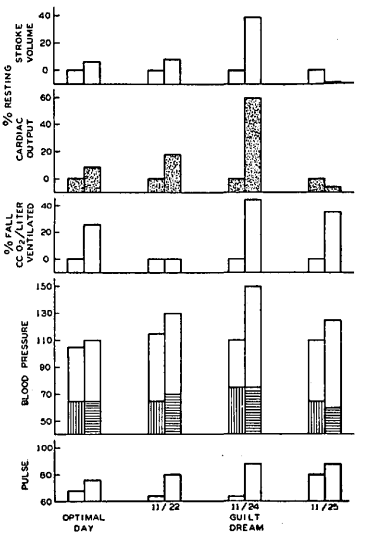

FIG. 8. Palpitation and increased stroke volume in addition to hyperventilation and a pressor response to exercise on the day following a guilt dream.

vated, and the utilization coefficient was depressed (fig. 8).

Comment: In the setting of marked underlying guilt the subject showed unusual levels of the cardiorespiratory functions after exercise adequate for the production of palpitation and other symptoms.

8. Palpitation occurring during the pre-menstrual period.

Subject 2 was noted to have changes in mood during the period of so-called pre-menstrual tension. From November 8 to 11 there were a series of home and work situations which resulted in mounting tension and frustration in the few days prior to the menstrual period. During the pre-menstrual period the subject became aware of her body with slight pelvic and breast discomfort and palpitation. Also, the declining energy made her less effective and caused her to drive more to accomplish her ends. She became resentful of "obstructions in her way." Menstruation had its onset on November 11. Figure 9 reveals these mood changes to be associated with elevation in cardiovascular function after exercise. The reactions returned to the usual levels with the onset of the menstrual flow.

Comment: The subject was in such a state in the pre-menstrual period that situations ordinarily easily managed constituted stress, and the total response to these situations was reflected in the function of the cardiovascular system.

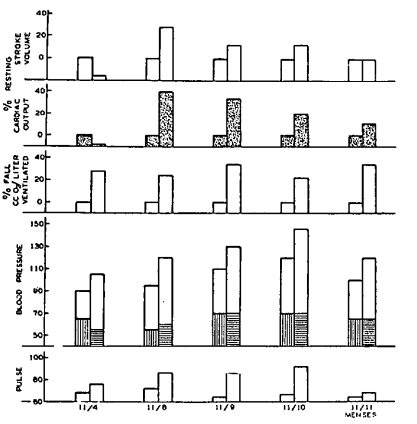

FIG. 9. Palpitation and increased stroke volume during a period of premenstrual tension.

9. Palpitation and tachycardia in an anxious man with a history of paroxysmal auricular fibrillation.

The patient was a 24-year-old male medical student who developed his first attack of paroxysmal auricular fibrillation following a period of extreme anxiety and fear of failure, and the imbibition of about five ounces of whiskey. There was no evidence of anatomical defect of the heart. Following the incident, his anxiety continued and he became, in addition, apprehensive about his heart in spite of reassurance. While in this state he was subjected to the standard Master Two Step test, and observations of his cardiovascular and respiratory functions were made before and after.

In figure 10 it is shown that his cardiac output had returned to the resting level by three minutes after exercise, but his stroke volume was reduced.

His pulse remained high, and his respiration and blood pressure were back to resting levels by three minutes after exercise.

Comment: This subject knew that he had always responded to exercise by a rapid pulse. He may be called a pulse reactor. This potentiality is interesting in relation to the attack of auricular fibrillation in the absence of anatomical heart disease. Levy *et al.* (38) present statistical evidence to support the hypothesis that this patient may be prone to the development of heart disease in later life.

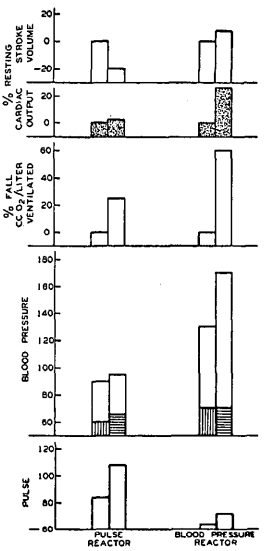

FIG. 10. Palpitation and tachycardia after exercise in a pulse reactor in contrast to increased cardiac output and increased blood pressure unassociated with symptoms in a blood pressure reactor. Both were tense and anxious but reacted differently to situational stress.

10. Palpitation associated with paroxysmal auricular fibrillation in a patient during periods of depression.

A 36-year-old female, without historical or physical evidence of a damaged heart and with a normal electrocardiogram, developed paroxysmal auricular fibrillation during periods of depression. She was a perfectionistic, dependent person who had a long history of recurrent psychoneurotic symptoms. She married in her middle thirties a man several years her senior. She demanded affection and close attention from her husband, who was neither inclined nor able to provide her with what she considered the requisites of a perfect marriage. After a prolonged period of frustration she would become anxious and depressed. She refused to leave her husband and considered suicide as the solution to her problems. As she became more depressed she would lose her appetite, lose weight and begin to vomit periodically. She became tearful and sleepless. During these periods she would develop frequent premature contractions, and on several occasions developed an attack of auricular fibrillation accompanied by palpitation which would last twelve hours and then subside spontaneously.

Comment: During periods of emotional stress associated with intense activity of the autonomic nervous system manifested by weeping and vomiting, this patient would develop paroxysms of auricular fibrillation.

Sometimes the intensity of heart sounds, the magnitude of stroke volume and the presence of palpitation appeared to be related. To define this relationship the following experimental procedures were undertaken on subject 1.

Relation of Palpitation, Stroke Volume and Intensity of Heart Sounds

It was noted in subject 1 that on days when the stroke volume was elevated for a prolonged period after exercise, he usually experienced prolonged palpitation after exercise. Inasmuch as palpitation in this subject was found to be associated with an increased recoil of the heart, as evidenced by an increased ballistocardiographic stroke, a study of the sound vibrations elicited from his heart was attempted. A Cambridge stethograph was used. Since variations in the position of the pick-up microphone, the intensity of pressure of the microphone bell against the chest wall and the setting of the volume control are known to interfere with the reproducibility of heart sounds, the following plan was adopted and observations were made daily during a month.

After the subject had finished the exercise and returned to the ballistocardiograph bed, the microphone was strapped to the chest, the volume control adjusted and records of the heart sounds, in addition to the ballistocardiogram, were taken at one, three and ten minutes after the end of exercise. The percentage fall in intensity of the first heart sounds from one to ten minutes after exercise was plotted against the percentage fall in the stroke volume during the same interval, and the resultant curve is shown in figure 11.

Comment: From perusal of the data, it is apparent that increased stroke volume, palpitation and increased intensity of heart sounds sometimes occur together. However, there were other occasions when palpitation and increased stroke volume could not be demonstrated to be related to increased intensity of the heart sound. This is not surprising when it is appreciated that there is probably no intimate relation between the displacement of the intrathoracic sensory end organs and the change in vibration responsible for the increase in heart sounds. It would seem reasonable to expect that occasionally, when the magnitude of the stroke volume change was great enough, such changes would reflect themselves in increased sound intensity.

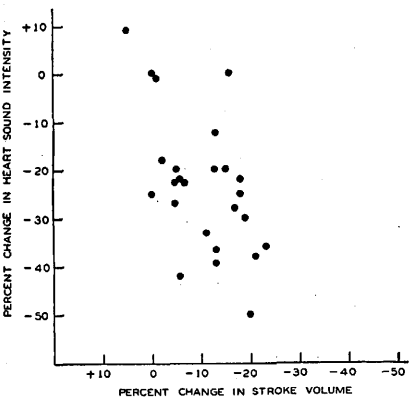

FIG. 11. Graph showing that although palpitation was associated with increased stroke volume, this was often though not always associated with corresponding changes in the intensity of heart sounds.

General Comment: From these data it is inferred that a significant change in stroke volume or in heart rate will cause mechanical disturbances such as traction and displacements within the chest, thus constituting adequate stimuli for the sensations interpreted as palpitation. It is, however, also apparent that subjects' attitude toward these sensations may become of major significance and be a factor in a chain of circumstances which accentuates or perpetuates the symptom. This may explain the frequent occurrence of palpitation in anxious patients with cardiac "neuroses," with and without structural cardiovascular disease. It may also indicate why patients with apparently adequate stimuli such as occur in auricular fibrillation do not always experience palpitation. For example, the attention of a patient can be drawn to the heart by means of the perusal of an insurance advertisement, a "check up" by a physician, a visit to a draft board, or the death of a friend from heart disease. If in such a circumstance the patient is having premature contractions, is lying on his left side in bed, is wearing a tight article of clothing about his chest, has indulged in unusual exertion, has experienced fear, or has an enlarged heart, auricular fibrillation, or some other arrhythmia, he may experience palpitation. In other words, certain attitudes as a result of conditioning in conjunction with minimal mechanical stimuli may result in palpitation. Either, alone, may produce no symptoms. Having once suffered the experience of palpitation, if the patient develops anxiety or fear of heart disease, increased attention to this area of the body plus a stimulus in the form of increased recoil of the heart or rapid pulse, associated with fear and anxiety, may potentiate the "vicious cycle," and the troublesome symptom of palpitation will exist. It is generally known that palpitation associated with premature contractions will disappear upon reassurance that heart disease is not present, although the premature contractions may persist.

Finally, since arrhythmias are so commonly associated with palpitation, their relation to distressing life situations and concomitant emotional reactions should be considered. It is known that the pulse rate and the electrocardiogram may be altered during fear or fright. It has been demonstrated above that a young man during a period of anxiety experienced paroxysmal auricular fibrillation with palpitation. Part of his reaction to exercise included a marked pulse rise with a slow fall to normal.

Premature contractions, paroxysmal auricular tachycardia and paroxysmal auricular fibrillation may be precipitated by disturbing life situations (69).

C. HEART PAIN

Pain arising from the heart is related to the amount of blood which the heart muscle is receiving through the coronary circulation and to the amount of work which the heart muscle is called upon to do. If the coronary blood flow is diminished by arteriosclerosis, by arterial thrombosis or by contraction of the arterial musculature (28), and is unable to meet the demands of the heart muscle, pain will result.

There are two types of reactions to adverse life situations which will be discussed in detail below, both capable under certain circumstances of produc-

ing pain. The first of these reactions calls for increased work of the heart, with either increased or constant coronary blood supply, and the second for a sustained amount of work from the heart in spite of a decrease in coronary blood supply.

The following protocols demonstrate the work demands upon the heart made during certain adverse life situations and concurrent feeling states. The first two protocols are those of younger persons in whom the demands of the heart muscle could be fulfilled by the coronary blood supply. The third protocol is of a patient in whom the demands upon the heart muscle were not only greater, but the coronary circulation was less adequate, with resultant pain.

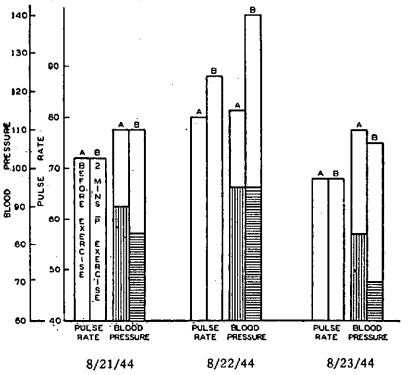

FIG. 12. Increased work of the heart after exercise (diminished exercise tolerance) during a period of fear.

1. Increased work of the heart associated with fear.

On August 22, 1944, after examining his acutely ill child, subject 1 concluded that his son probably had anterior poliomyelitis. The dominant emotional response was fear. In contrast to the usual resting pulse rate of 68 per minute, the pulse rate was 80 per minute. Two minutes after exercise the pulse rate was 88 per minute, contrasted to 68, and the blood pressure was 140/95, contrasted to 105/70 (see fig. 12).

Comment: A period of stress associated with fear resulted in a rise in the resting blood pressure and pulse rate, and a less rapid recovery from the effects of exercise. In no instance in the nine months of observations was there so sustained an elevation of the resting or the post-exercise pulse rate. Furthermore, on no other occasion was the combination of pulse acceleration and elevated systolic blood pressure observed in this individual. Under these circumstances the work of the heart was presumably increased and the myocardial requirements for blood augmented. The coronary blood supply was adequate to meet the demands of the myocardium.

2. Increased cardiac work in a driving, perfectionistic man.

The subject was a 24-year-old male medical intern. He was an ambitious, driving, meticulous person who felt insecure in the hospital post he had achieved because of good academic performance, and was under considerable stress in maintaining the standards which he believed were inherent in his job. He was extremely sensitive to disapproval and was uncertain whether or not his performance was successful. He worked under tension. He enjoyed good health and had no complaints.

The response of the function measured is illustrated in figure 10. It will be noted that for a given amount of exercise for his age and weight, which in most persons results in a return of the pulse and blood pressure to resting level by two minutes after exercise, the blood pressure, cardiac output and the fall of the utilization coefficient were unusually high. The pulse reaction was not marked.

Comment: This observation represents an instance in which work of the heart was increased, in that blood pressure and cardiac output returned to resting levels slowly after exercise. Stead *et al.* (60) and Grollman (30) have also shown that the cardiac output may be increased in response to stress-producing situations. As shown by Thacker (62), this is a characteristic response of persons who have an elevated blood pressure under the stress-producing circumstances of a "physical examination." Levy *et al.* (37) have shown that those who have transient rises of blood pressure under the circumstances of such a medical examination are more liable to develop hypertensive disease, which is commonly associated with angina pectoris in later life. In any event, given anatomical impairment of the coronary blood flow, such a patient is prone to the development of coronary insufficiency as illustrated in the following protocol.

3. Increased cardiac work and precordial pain associated with rage in a man with hypertensive cardiovascular disease.

The subject was a 50-year-old Jewish male "cloak and suit" worker who had transient hypertension ten years before. He complained of substernal pressure and painful precordial sensations not related to exercise, lightheadedness on exertion and head-

ache. His symptoms had appeared following a recent upper respiratory infection. His examination revealed a blood pressure of 210/120 and a slightly enlarged heart. His electrocardiogram showed depression of ST 1 and 2 and low amplitude of T 1 and 2 and slight left axis deviation. The patient was interviewed on the ballistocardiograph bed, and respiratory, pulse, blood pressure, and cardiac output measurements made. The interview revealed that the subject had an uncompromising, demanding wife who imposed her relatives upon the patient in his business, who "cared" little about his personal well being. She complained when the patient felt obliged to visit his aged mother; but when the patient acquiesced to her demands and remained at home, she went out to visit her friends and left

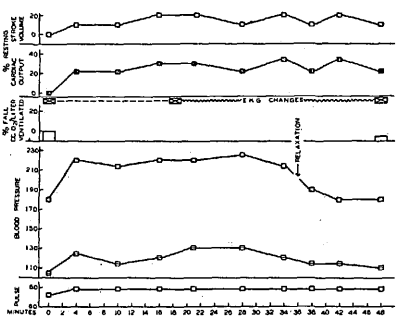

FIG. 13. Increase in blood pressure and cardiac output (cardiac work) in association with rage. E.K.G. changes and precordial discomfort indicated by wavy line. Relaxation suggested but incompletely achieved indicated by arrow.

the patient alone. While describing these facts, the subject at first sobbed and then became angry and poured out examples of his wife's iniquities. He complained that the "aggravation" aroused by the discussion was characteristic of what he experienced much of the time, especially when at work or at home. Specifically he noted choking sensations, substernal pressure without radiation and occasional giddiness. Figure 13 shows that the blood pressure and cardiac output rose during the interview. The electrocardiogram changed slightly but definitely towards a more normal configuration with elevation of the ST segments and of the T waves which Master considers a positive test for coronary insufficiency. The functions did not return to resting levels at the end of the interview and reassurance was not effectively produced. Respiratory tracings showed shallow rapid respirations identical before and after the interview. The same electrocardiographic changes were produced by the Two Step test.

Comment: The cardiovascular reactions in association with rage in this patient, with presumed irreversible vascular disease, are comparable to those found in subject 1. It is of interest that the electrocardiographic changes resembled those seen after ergotamine in patients with neurocirculatory asthenia (68). Loftus, Gold and Deithelm (39), and Mainzer and Krause (40) have demonstrated electrocardiographic changes associated with fear. Graybiel *et al.* (29) and Thompson (64) have made relevant observations. Master, Nuzie, Brown, and Parker (42) have described in a given patient greater changes in the electrocardiogram during periods of "intense nervousness" than could be produced by the Two Step test or by breathing 10 per cent oxygen when the patient was "at ease."

The second category of "heart pain" or precordial discomfort in association with adverse life situations includes, as mentioned above, those instances in which sustained demands on heart muscle are not accompanied by increase in cardiac output but may indeed be accompanied by a decrease. This combination may lead to pain and, possibly, to coronary thrombosis.

1. Decrease in the stroke volume associated with hypodynamic states and its relevance to diminished coronary blood flow and precordial pain.

On October 23, 1944, shortly before the observations of the day were made, subject 1 was interviewed by a special feature writer from a well-known pictorial weekly concerning a proposed popular article on a medical topic in which he was deeply interested. The subject reacted enthusiastically to the proposal and gave considerable information to the reporter. Some of the information essential to an adequate statement of the problem was still unpublished. He was in conflict, but this he resolved because he was convinced that the popular magazine article would exert a widespread constructive influence. He was also certain that the data would have reached the stage of formal presentation by the time that the popular article was to be published. However, after the experiment he discussed the matter with his senior officer who assumed a non-committal, judicial attitude and failed to support the subject in his decision. This reroused the conflict, and the subject developed feelings of guilt and a conviction of lack of support —akin to betrayal.

On the evening of October 24, a group of friends, supposedly sympathetic persons with ostensibly the same values as the subject, announced their aban-

donment of these values and the adoption of an entirely different orientation. This was the second of a series of assaults through which the subject's props were cut from under him, reenforcing his feelings of lack of support and of having been "sold down the river." These reactions and moods persisted through October 27. Throughout this time the subject experienced feelings of sadness, bewilderment, cynicism, and defeat, and felt, figuratively, as though the bottom had dropped out and he had had the "heart taken out of him." He complained that he had slept poorly, had no energy and had lost interest in his work. He listlessly attended his responsibilities. (The case notes included the following descriptive comments: bewildered, confused, saddened, "not knowing where I stand,"

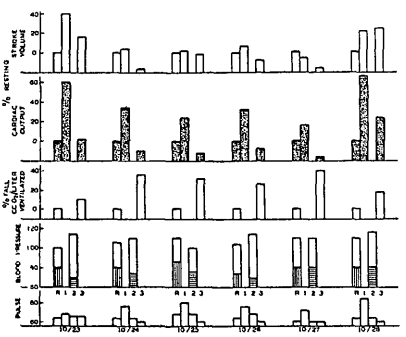

FIG. 14. Cardiovascular function (fall in stroke volume after exercise) during a hypodynamic state. 10/23 and 10/28 are considered optimal days.

feelings of being "let down by those I felt would support me," shakiness, slightly facetious—subject taps fingers against bed. Subject's initial statements, however, were "in good spirits, slightly tense, good energy, and good effectiveness." The last day of the series he said, "I'm weary—it's the end of a long series of long days.")

Figure 14 demonstrates the cardiovascular and respiratory functions before and after exercise during this disturbed period. It will be noted that the resting pulse, blood pressure and cardiac output were low and that after exercise they fell to levels actually below the resting levels. The fall in cardiac output was due not only to a fall in pulse but to a fall in stroke volume as well.

Comment: The reaction described in subject 1 was a less common response to assault and in essence was a lying down or failure to strike back. The defeatist feeling seemed to be reflected in the bodily reactions. It may be analogous to the "sham death" or collapse reaction seen in sheep, opossums and sometimes in man. It is probable that this fall in cardiac output represents a defect in venous return to the heart caused by pooling of blood in the periphery. Since hyperpnea existed in all of these subjects, it is unlikely that the fall in venous return to the heart is of respiratory origin. Starr (56), using the ballistocardiograph, found in a group of people including both healthy and "sick" persons that a burden analogous to exercise, namely, assuming the erect position or merely the stress produced by the experimental procedure, caused a decrease in the cardiac output. Starr and Jonas (54, 55) have also described a syndrome of subnormal circulation. Thacker (62) has studied the effect of repeated blood pressure examinations on young men. He has found that those with arterial hypotension on initial medical examination were on subsequent examinations found to have normal levels of blood pressure just as the blood pressure in young men with hypertension falls to normal levels. It appears that an initial examination is a stress-producing situation and that the response may be either blood pressure elevation or depression. With reassurance and familiarity with the procedure, the blood pressure falls or rises to normal levels in subsequent examinations.

Bansi and Grosscuth (8) noted a marked drop in the minute output and stroke volume after exercise in a patient who happened to have mitral stenosis. Simonsen and Enzer (51) state that collapse may be observed in normal subjects after heavy exercise. Whitehorn *et al.* (70) have described decelerations in the pulse associated with feelings of "dejection, aversion and resignation." Ziegler and Levine (73) have described a fall in basal metabolic rate with similar feelings. Another indication that hypodynamic responses to stress-producing life situations occur is the frequent complaint of lightheadedness in patients with neuroses. The low blood pressure sometimes found in dejected, discouraged, listless persons may be a manifestation of such a reaction. Hamilton (31) has also observed low blood pressure associated with emotional stress.

The fact that coronary thrombosis occurs frequently in persons with hypertension does not minimize the possible importance of the hypodynamic reaction in coronary thrombosis. A fall in the cardiac output such as noted in the hypodynamic response is not necessarily related to the resting level of the blood pressure. Therefore, in the presence or absence of arterial hypertension,

the hypodynamic reaction with a fall in cardiac output may significantly alter the coronary blood flow. Such reactions may be important in patients with coronary artery sclerosis or other heart disorder which impairs coronary circulation. If the blood supply is inadequate to the needs of the myocardium, precordial pain may result. It is of interest that Dunbar (20) has observed in some patients with coronary occlusion that "the major emotional factor was usually a disappointment in relation to vocational life: 'After working so hard all those years, I had just reached the top and was happy, when this happened, and it was all taken away'; or, 'I wasn't my own boss any more.' Although death or illness of parent or spouse was usually mentioned as having occurred just prior to the onset of the illness, the patient was inclined to minimize the emotional importance to him of such events; instead, the specific reference was likely to be to eating or nightmares about fighting or to financial reverse."

That the hypodynamic reaction may be relevant to the production of "heart pain" in certain instances of "angina pectoris" is demonstrated by the following protocol.

2. Precordial pain and diminished stroke volume associated with feelings of rage, desperation and defeat in a patient with angina pectoris.

A 46-year-old man with a characteristic history of angina pectoris but with a negative electrocardiogram and anoxemia test was studied. The electrocardiogram did not change after exercise even though pain was produced. The patient was interviewed while the various physiological functions were recorded. He told of having a common-law wife whom he loved. This woman was unfaithful and he bitterly resented her "affairs" with other men. He also resented the fact that his son was kept in a foster home by the courts. His precordial pain initiated by effort was usually present while at work and during the exertion of walking away from the foster home where he had left his son, after their weekly visit.

During this account the patient became very angry, and his face flushed. His mood changed from anger to desperation as he related that his wife would neither remain faithful, assume any responsibility for their child nor give him its custody. He had tried every device from persuasion to threats, having once been arrested for carrying a revolver, but all to no avail. While discussing his wife's promiscuity and shameless irresponsibility towards their child, he uttered a loud, sardonic, prolonged laugh. He wished to have the child cared for in his sister's home under his own guidance but he felt helpless before his wife's scorn and under the court's decision that the child should remain in a foster home. He saw no avenue of escape, no hope for the resolution of his dilemma.

Observations during the interview are shown in figure 15. There was a slight pressor response. There was a fall in the pulse rate and a fall in the stroke volume. During the interview the patient complained of precordial pain, although electrocardiographic changes did not occur.

Comment: This subject demonstrates a fall in the cardiac output in spite of a slight rise in blood pressure in response to recall of affect-laden facts. It is possible that the fall in cardiac output was reflected in a decrease in the coronary circulation,

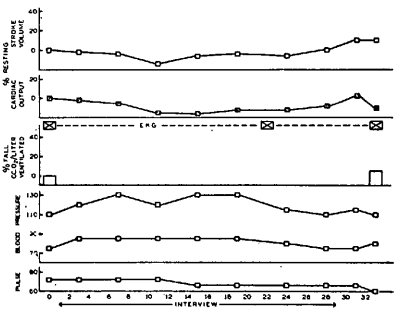

FIG. 15. Fall in cardiac output and stroke volume, and the occurrence of precordial pain during a period of frustration and feelings of defeat.

especially if coronary artery constriction (28) were associated with the slowing of the heart (increased vagal activity). The supply of blood to the myocardium would be enough below the demand of the heart muscle to result in relative anoxemia and pain. In all events, in this patient pain occurred when the cardiac output fell.

3. Myocardial anoxemia associated with pain occurring during sleep in a desperately unhappy, dejected man.

A 35-year-old normal healthy male took a vacation during which he led a very active life. On one occasion he ran 100 yards in a foot race at top speed without experiencing precordial pain. One week after returning home he retired for the night and awakened with aching substernal and precordial pain which persisted for three to four hours. An electrocardiogram revealed depression of ST 2 and 3 and negative T 2 and 3. The QRS complexes

were not involved. The patient recovered after three weeks' bed rest and was asymptomatic. The electrocardiogram returned toward normal in six weeks. The presence of fever, leukocytosis and elevated sedimentation rate were unknown.

Questioning as to his feelings preceding the coronary accident on the night of the episode revealed that the patient was dejected, lonely and bored prior to retiring, but the state itself was not unusual for him.

Comment: It is probable that little coronary artery narrowing was present if the patient could tolerate a 100-yard run without pain. Nevertheless, while asleep the patient experienced a serious alteration in his myocardial blood supply. It is possible that diminished blood supply was dependent upon the hypodynamic reaction described above.

It is apparent from the above that both hyper- and hypodynamic reactions are relevant to heart pain. Although it is generally accepted that a rise in cardiac output and subsequent increase in the work of the heart are more effective in producing myocardial ischemia and pain, a fall in minute volume would also decrease the coronary blood flow and, in addition, given a pre-existing occlusive disease of the coronary arteries, could present an optimal state for the development of myocardial infarction. Such a set of circumstances would explain some instances of anginal or coronary thrombosis occurring in individuals during inactivity or immobilization in bed and accompanying surgical shock.

In summary, additional evidence is presented that work performed under emotion-producing stress may be associated with a rise in the work of the heart, myocardial ischemia and cardiac pain, if coronary artery narrowing is present. During stress-producing life situations, reactions characterized by a prolonged elevation of the cardiac output after exercise, or a fall of the cardiac output after exercise below the resting level, have been described.

D. FAINTING AND GIDDINESS ASSOCIATED WITH CARDIOVASCULAR AND VENTILATORY DISTURBANCES

Inasmuch as disturbance of the blood supply to the brain is a common cause of giddiness and fainting, a study of the circulatory and ventilatory functions known to be related to the blood flow in the brain was undertaken. Romano and Engel (48) have demonstrated by means of the electroencephalogram that significant alteration in the electrical activity of the brain occurs concomitantly with the fall in blood pressure in persons during fainting.

To investigate one mechanism of giddiness, cardiac output and cerebral blood flow were decreased by increasing intrapleural pressure. This was done by the method of decreasing venous return as devised by Flack (24) as follows:

The symptomatic and blood pressure changes in response to sustaining a column of water 20 cm. high for twenty seconds by blowing, while the subject passively leaned against a board at a 70 degree angle from the horizontal, were observed in subject 1 daily for a period of three months. On optimal days, which constituted approximately four-fifths of the time, there was but a slight fall in the pulse pressure while sustaining the column of water, and no giddiness. However, protocol No. 1 is a representative instance of those experiments on suboptimal days during which unusual responses were present.

1. Giddiness associated with a fall in pulse pressure during the "Flack test" and during a period of marked fatigue.

The second week in February was a period during which subject 1 was experiencing excessive demands upon his time and energy. He reacted to this situation with feelings of extreme exhaustion, using the word "pooped" to describe his state. He also noted during this period that he felt lightheaded upon sudden change of position from supine to upright. The top row of figure 16 contrasts the amount of fall in pulse pressure on optimal days when giddiness did not occur with that on February 13 when the subject experienced giddiness. On that occasion, while sustaining the column of water, he had marked fall in pulse pressure, and therewith he experienced giddiness.

Comment: Gambill, Hines and Adson (27) have demonstrated that similar changes in the response to the Flack test can occur after a prolonged period of immobilization and after sympathectomy. Weiss *et al.* (66) have studied the mechanism of postural fainting after the ingestion of nitrites and have concluded that there is a decrease in venous tone with resultant pooling of blood in the extremities (59). On the basis of the available evidence it is likely that, under circumstances of stress, peripheral vascular changes occur which result in an impaired venous return to the heart. Under these circumstances the added impairment of venous return effected by increasing the intrathoracic pressure may be sufficient to reduce the cardiac output to such an extent that there is decreased cerebral blood flow, with resulting giddiness or fainting.

Another mechanism concerned in the production of giddiness may be hyperventilation with resultant

low CO_2 content of the blood. Thus, Soley and Shock (52) have inferred from their studies that hyperventilation may cause light-headedness in neurocirculatory asthenia. Wolff and Lenox (72) have shown that low carbon dioxide content of the blood may result in cerebral vasoconstriction. Also, the dissociation of oxyhemoglobin at low oxygen tension is inhibited under circumstances of low CO_2 content of the blood (10). These changes may be associated with cerebral anoxia and light-headedness. Forced ventilation readily produces

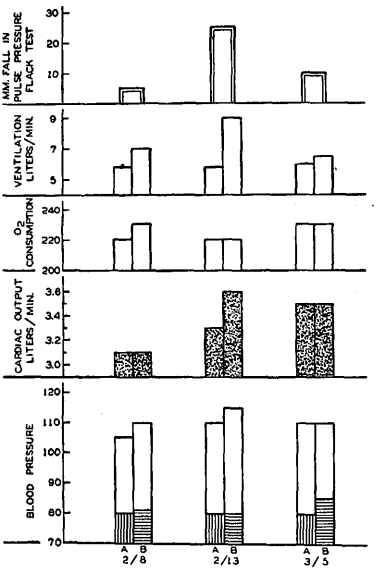

FIG. 16. Giddiness associated with an abnormal Flack test and hyperventilation without increase in oxygen consumption after exercise during a period of marked fatigue on February 13.

giddiness. It has been possible in these experiments to produce giddiness as well as other symptoms of his illness in a young man with hyperventilation syndrome. This was done by allowing him to inhale a low oxygen mixture in a closed system from which the CO_2 was being constantly absorbed. Identical symptoms were readily produced in symptom-free healthy persons by the same procedure. That the changes brought about by hyperventilation may be relevant to the problem of giddiness and faintness occurring in response to stress-producing life situations is illustrated in the following protocols.

2. Giddiness during a period of marked fatigue and impaired ventilatory function.

During the same period in February in which subject 1 was exhausted and experienced giddiness on changing position, it was noted on February 13 that not only was the Flack test abnormal, but also hyperventilation after exercise was present. Figure 16 illustrates the increased circulatory response and the increased ventilatory response to exercise on this day of marked fatigue as compared with optimal days.

Comment: It is suggested that hyperventilation occurring during the period of stress contributed to the occurrence of light-headedness when this was added to the burden of change in position or fall in pulse pressure.

3. Giddiness as a result of hyperventilation in a patient with fear of heart disease.

A 60-year-old male, who was a hard worker and was holding down a daytime job in addition to a piece-work job from 7-12 p.m., had been examined by an industrial physician as part of a pre-employment program and told to see a heart specialist. He did, and the "specialist" told him that he had a heart murmur but not to worry about it. The patient, after a year of working at the two jobs, suddenly became very exhausted and quit his jobs to take a vacation. Following the vacation he noted light-headedness at rest, which disturbed him, and he subsequently sought medical advice. The patient spoke and acted as though he were convinced that he had serious heart disease. He felt that the doctors were withholding the serious information from him. Examination revealed a normal blood pressure. There were no signs of an intracranial lesion or of congestive heart failure. There was a harsh systolic murmur at the base, not transmitted, and unaccompanied by a thrill. A_2 was present. The heart was slightly enlarged to the left. An electrocardiogram revealed left axis deviation and some diminution in the amplitude of the T waves. While having the patient overbreathe during auscultation of the lungs, his symptoms were reproduced. The Master Two Step test was normal as regards pulse and blood pressure, but hyperventilation persisted and the patient again experienced a recurrence of his symptoms. It then became clear that the patient was overventilating, and when informed of this the patient in surprise stated he did this voluntarily because he felt that an adequate intake of air was beneficial to a man with heart disease. Explanation and reassurance resulted in disappearance of the symptoms.

Comment: In this instance the occurrence of fear

was associated with voluntary hyperpnea which resulted in giddiness.

4. Fainting caused by hyperventilation during periods of anxiety, guilt and depression.

A 56-year-old male patient complained of fainting spells for two years. The episodes were precipitated by a feeling of oppression in the chest with the desire to sigh. The patient would then begin to pant rapidly and subsequently pass into a semiconscious state. The patient was a divorcé who had had an extremely unhappy married life and had eventually been repeatedly unfaithful to his hated wife. At the onset of his illness a friend had embezzled money from him.

In the absence of "true friends" and family he became lonely and dejected, anxious about his health and guilty concerning his sexual promiscuity.

Comment: In this instance it is likely that the fainting episodes were dependent solely upon the physiological changes brought about by hyperventilation.

Since giddiness, fainting, palpitation, and fatigue are common accompaniments of the first period of convalescence, it became pertinent to analyze the symptoms in terms of the bodily function under consideration. Convalescence may be looked upon as a period of readjustment to change of position and unaccustomed effort, as well as other more complicated personal and social changes. The following patients, though they complained relatively little, were selected for study for technical reasons. They demonstrate clearly the types of bodily changes pertinent to the aforementioned symptoms.

5. Cardiovascular and respiratory function and its relevance to giddiness during convalescence in 3 patients during recovery from acute illness.

Patient 1 was a 15-year-old boy who was studied on the fourth, fifth, sixth, and seventh days after initial mobilization following pneumococcal pneumonia. He had no complaints, but when pressed he admitted that he lacked energy, was restless and desirous of leaving the hospital. His energy improved and his restlessness increased from the third to the seventh day. In figure 17 changes are noted in blood pressure response to exercise, and the resting levels rose as time progressed. The cardiac output was elevated 18 per cent above the resting level on the first day. The fall in pulse pressure during the Flack test was marked early in convalescence but rapidly returned toward a normal response.

Patient 2 was a 21-year-old nurse who suffered a mild gastroenteritis and was in bed for three days. On the day of mobilization, minute ventilation was high, although oxygen consumption was not elevated before and three minutes after exercise. The patient complained of dyspnea after exercise. The Flack test showed changes similar, though less marked, than those of the previous patient.

Patient 3 showed changes in different categories of cardiovascular function. She was a 17-year-old female who had recovered from diabetic acidosis. Blood pressure and oxygen consumption were elevated three minutes after exercise, and ventilation was elevated only after exercise. These changes progressively disappeared by the sixth day after mobilization. She complained of palpitation after exercise on the first day.

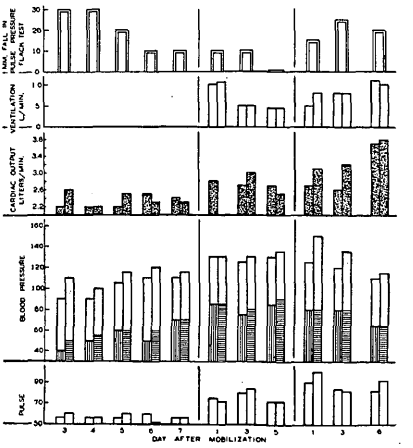

FIG. 17. Circulatory and respiratory responses to exercise in three patients during convalescence from acute illness. Note different categories of reaction in different subjects.

Comment: Although these patients were relatively free from symptoms, the qualitative circulatory and ventilatory changes appear to be relevant to the problem of giddiness and, incidentally, to palpitation, dyspnea and fatigue occurring after prolonged immobilization and analogous to those changes which we have demonstrated to occur in response to other stress-producing life situations. Deitrick, Whedon, Shorr, and Barr (18) have demonstrated in normal persons change in the tilt board fainting time during "convalescence" after prolonged immobilization. Relevant also to the problem of circulatory changes and giddiness is the work of Mayerson and Burch (43), and Allen, Taylor and Hall (6). These authors studied syncope induced by gravity on the tilt board and found

that patients with impaired exercise tolerance (prolonged elevation of the blood pressure or pulse after exercise) were more likely to faint on the tilt board than others who had normal exercise tolerance tests. In one patient the time in the tilted position necessary to produce fainting increased coincidentally with the improvement of an adverse life situation.

6. Giddiness in a patient who feared death during the period of recovery from a myocardial infarction.

A 45-year-old banker with a long history of being resentful, insecure and not well-liked by his coworkers suffered a coronary thrombosis. By five weeks after the original accident his temperature, pulse, WBC, and sedimentation rate had returned to normal. His electrocardiogram had stabilized. He was mobilized gradually and without warning of possible symptoms he might experience on getting out of bed. He subsequently experienced palpitation and tachycardia (he took his own pulse), light-headedness on standing and muscular weakness. He mentioned these symptoms, but again their lack of significance was not explained to him. The next day he arose, had similar symptoms, and in addition this time had marked sweating and palpitation but without precordial pain or other evidence of another infarction. Fear and anxiety had become a feature of this man's illness and were associated with symptoms which suggested to him that the function of his heart was seriously impaired. Indeed, there was little doubt that the symptoms were the result of five weeks of hospital experience.

Comment: The above is an example of an anxious man who, during an illness and in a hospital setting, became involved in a vicious cycle with progressive elaboration and intensification of symptoms. Thus, fearful of the implications of his coronary disease and ignorant of the anticipated circulatory derangements of mobilization, he overreacted to the palpitation and giddiness which accompany the first hours of mobilization. These symptoms thus gave rise to anxiety which, in turn, as we have shown, may be associated with augmentation of cardiac output and ventilation. With such increased intensity of the symptoms, the patient became further alarmed, with further derangement of function and exacerbation of symptoms. This spiraling of events severely impeded convalescence and prolonged hospitalization.

E. FATIGUE

The term fatigue as applied to the description of a patient's complaint lacks clear definition and indeed may refer not only to sensations arising in the body but also to the attitude of the patient toward the task to be accomplished. Thus, any of the following may be interpreted by the patient as fatigue: the aching in the muscles following intense physical exertion; the feeling that a task usually accomplished with a minimum of shortness of breath, palpitation and sense of bodily warmth calls forth more than a minimum of these sensations; the feeling of revulsion towards an unpleasant or undesirable task; the feeling of conflict in the absence of a dominant motivation or drive towards the accomplishment or performance of one's daily duties. Fatigue as it is encountered in patients is most apt to present itself during submaximal exertion and possibly explains the variability and unpredictability of results that occur in studies on submaximal exertion (19, 51, 25).

It has been indicated above that during periods of anxiety, tension and fear, the pulse, blood pressure, ventilation, stroke volume, and cardiac output have remained elevated for a longer period after exercise, indicating that under these circumstances the work of the heart and respiratory mechanism is increased, making fatigue in its overall sense more likely. Also, it has been shown that some of these changes are found in association with the fatigue of convalescence.

1. A simple experiment revealed the following: Two normal males were made to sustain a 1 Kg. weight attached by a system of pulleys to the fifth finger by flexion of that finger. The time during which the weight was sustained and the height at which it was maintained were recorded. From a total of 18 observations it was found that on the days when the subject claimed to feel "energetic" and "effective," he held up the weight longer than at other times. One subject revealed, in addition, the effect of training in that he could sustain the weight longer at the end of the experimental period than at the beginning.

It is obvious that the work done represented more than a simple fatigue phenomenon at the neuromuscular junction. Various factors operating at the time the test was performed included the following:

(a) The day's schedule of the subject—whether he had many or few responsibilities.

(b) The presence of distractions, such as entertaining conversation during the test.

(c) The occurrence of stiffness and pain due to the cramped position of the arm during the test rather than true neuro-muscular fatigue.

(d) The feeling of exuberance or high energy as reported by the subject.

There is evidence to suggest, therefore, that when a given amount of work is undertaken under emotional stress, the exercise tolerance and, thus, the relative efficiency of the subject may be impaired. In addition, the duration of work and the amount of work which can be tolerated is dependent upon attitude, motivation and attention. Thus it is probable that true neuro-muscular fatigue rarely occurs during submaximal exertion. When fatigue is described as a symptom, one is usually referring to boredom, inattention, conflict due to lack of dominant motivation, the uncomfortable sensations due to the contraction of infrequently used muscles, or to the overall result of working in an unsatisfactory environment. There may be, in addition, slight inefficiency in function, which manifests itself to the patient in that he is unable to accomplish a given task with the same effort as previously.

2. Inefficient cardiovascular and respiratory reactions and fatigue associated with an upper respiratory infection—"common cold."

On October 6, 1944, subject 2 had been "exposed to a cold" and on the following day made the statement that she felt as if she were fighting off a cold. Two days later, the subject stated she had chilly sensations and stuffiness of the nose. Three days later, she developed frank coryza, post nasal drip, muscle aches, and stuffiness in the right ear. She experienced conflict between the dominant motivation to keep on working and the wish to "give up and take care of myself." On the 13th, her symptoms subsided rapidly, and on the 16th she had no complaints.

The changes in the pulse, blood pressure and cardiac output are shown on figure 18 during the course of this minor illness. It will be seen that the pulse, blood pressure and cardiac output were elevated to a greater level than usual after exercise, during the period of her illness.

Comment: The subject had the poorly-defined symptoms which accompany a "cold," such as loss of energy and difficulty in performing usually easy tasks. It would appear that the primary defect was reflected in the cardiovascular system when it was subjected to exercise. This chain of circumstances may be related to the common clinical experience of decompensation in diseased hearts occurring at the time of some minor infection, such as a "cold." The emotional response to the situation of the "common cold" is variable. It includes resentment, conflict over the desire to keep on working and the desire to rest and "treat the cold," fear that the upper respiratory symptoms might be the prodromal state of some more serious disease, and fear of the commonly publicized sequelae of complications of a cold. Therefore, the total response of the individual to infection by the virus of the "common cold" includes emotional and associated cardiovascular reactions.

3. Diminished exercise tolerance with fatigue during an infectious gastroenteritis.

Subject 2's immediate family all had had attacks of nausea, vomiting and diarrhea, associated with fever. She had cared for them during their illnesses. The day after the last one had recovered, the subject herself noted watery diarrhea, abdominal cramps, anorexia, and nausea. The dominant mood reaction was one of defiance. The subject had made up her mind that she would surmount the disability and perform her duties. She was exhausted and could hardly finish the day. She stated that she had performed her work adequately but that she felt that it had required more drive. She said that this behavior was "worth the price" because it sustained her system of security. Her temperature was 37.4° C. by mouth at the time of the experiment. The pressor effect after exercise is shown in figure 19. The other functions were not involved.

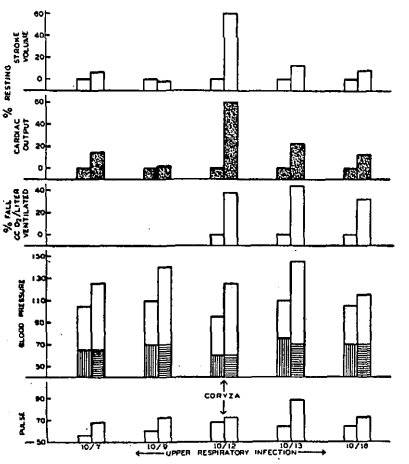

FIG. 18. Inefficient circulatory function (stroke volume) associated with fatigue during an upper respiratory infection. 10/7 and 10/16 are considered optimal days.

Comment: The factors of systemic infection, dehydration and lack of food, together with her defiance of the illness, constituted the situation which was reflected in a slow return of the blood pressure to resting levels after exercise and associated fatigue.

4. Diminished exercise tolerance with fatigue following a sleepless night.

Subject 2 spent the evening visiting night clubs with an old friend. She consumed only a small amount of alcohol but danced many hours and had only three hours' sleep before coming to work. She performed adequately at work but complained of feeling fatigued, very warm, dry eyed, and lacking in energy. Figure 20 demonstrates the cardiovascular and respiratory function on that day.

Comment: The reaction to an exhausting but pleasant evening with very little sleep included profound changes in cardiovascular function.

From the standpoint of application of these principles to patients, when searching for the cause

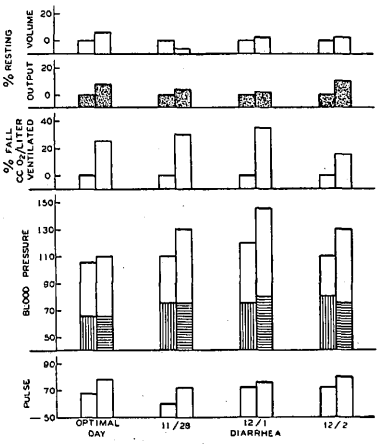

FIG. 19. Inefficient circulatory (blood pressure) and respiratory function associated with fatigue during an infectious enteritis.

of fatigue, one should explore the attitude and motivation of the individual toward the task in which the fatigue develops. Furthermore, removal of the patient from the stress-producing situation in which the fatigue occurs reduces such fatigue.

5. Variation in blood pressure response to exercise on the different days of the week.

Subject 1 had a very highly organized work schedule for the week. Although the duties undertaken on the different days of the week varied, essentially the same activities were engaged in every Monday, every Tuesday and so on through the other days of the week. The greatest of responsibilities was present during the latter half of the week when teaching, clinic and other demands were greatest. Saturday was less pressing, but a full day's work was indulged in. Monday found the subject rested but having some difficulty attempting to get back into "the swing of things." The daily incidence of blood pressure readings

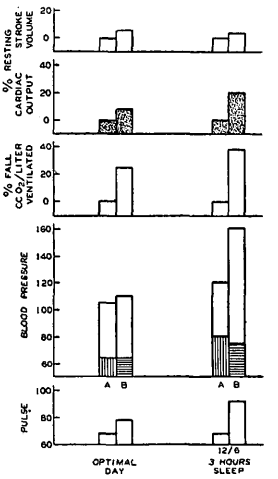

FIG. 20. Inefficient circulatory (blood pressure and pulse rate) and respiratory function associated with fatigue following a sleepless night.

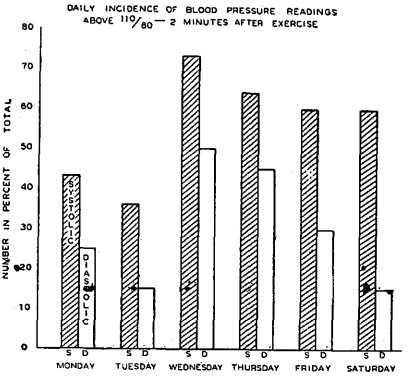

FIG. 21. Per cent of blood pressure readings elevated after exercise plotted on the days of the week. Note the change in pattern as the end of the week and increasing responsibilities were approached.

above 110/80 two minutes after exercise was plotted for all the days of the week during each half of the total period of observation. The two curves were found to superimpose with accuracy, and the resultant of the two curves is plotted in figure 21.

Comment: It has been shown that the day-to-day variations in the adverse situations experienced in every day life, if they have a definite pattern, may reflect themselves in the individual's ability to tolerate exercise. In addition, these bodily reactions contribute to the fatigue which usually appears during the latter half of the work week.

GENERAL COMMENT

Statements in the literature concerning the "effect of anxiety on bodily functions" are common. Unfortunately, such references focus attention upon the emotional aspects of the response to a situation rather than upon the effect of the situation on the entire organism. It is the latter concept which is of importance to the physician.

Familiar responses of the cardiovascular system to stress-producing situations include a change in the heart rate (70, 71), rise in blood pressure (2, 3, 49, 65), change in the contractile state of the blood vessels of the skin (45, 46), increase in the cardiac output (30, 60), alteration in the respiratory rate and depth, and, more specifically, increased ventilation in response to painful stimuli without increase in the oxygen consumption (4, 10, 11, 14, 22, 23, 34). In terms of the methods employed, the aforementioned studies were of two types. The larger group consisted of observations and attempted correlation of the physical manifestation, and emotional and other feeling reactions in psychologically maladjusted patients. The smaller group consisted of descriptions of the reactions to laboratory situations designed to arouse anxiety or other emotional responses. The orientation in this study is that the reactions of the individual in and to his every day environment are more relevant to disease than are his responses to a startling noise, a sudden frightening experience or during an affective state induced by hypnosis.

Previous, accurate, experimental studies of the cardiovascular system have been made on subjects who are far removed from their usual environment. The rigid definition and utilization of the so-called basal state has been attended by reproducibility of results with methods of extreme accuracy. This situation is obviously ideal to assess the effect of a single drug or simple stimulus on an organism which is removed from other stimuli. However, little attention has been paid to the effect of diffuse and complicated environmental stimuli on the organism (7, 12, 67).

The method of following the subject from day to day for a long period of time and noting his attitude, amount of talk, the speed, grace and amount of body movement, gestures, posture, general behavior, facial expression, sleep, dreams, his statements as to situational factors, his affective state, and his cardiorespiratory functions indicated that situational factors cause drastic changes in cardiorespiratory functions. It has been shown that these contribute to the causation of symptoms in patients and that they constitute a factor in the precipitation of crises, such as cardiac failure, in the cardiovascular or respiratory systems.

The question might arise as to whether feelings of which the individual was not fully aware might explain the apparent lack of association in some instances between emotions and cardiorespiratory changes. Despite the fact that the data in this study includes observations upon performance and behavior, as well as the interpretation of dreams, and thus includes information concerning the affect possibly not recognized or reported by the subject, it was impossible for the examiners to appraise the dominant affect or the psychodynamics in many instances.

Situations which constitute every day life, although they may produce a predictable response in a given subject, are essentially non-specific. Unless the past experience (previous conditioning) of the subject is known, there is no way of foretelling the character of the emotional and physical responses to a situation. Indeed, it has been observed that the intensity and duration of the responses depend upon the past conditioning of the subject and, in addition, upon the pressure of responsibilities present at the time the situation occurs.

It has been shown that specific associations between a given emotional response and the physical response to a situation do not always occur. However, to a certain extent the hyperdynamic reaction was associated with rage, fear, anger, resentment, and anxiety. On the other hand, the hypodynamic reaction suggesting a failure to strike back against an assault was associated with feelings of hopelessness and defeat.

SUMMARY

Day-to-day studies were made over a period of almost a year of the symptoms and cardiovascular and respiratory functions of healthy human subjects, and short term observations were made on selected patients.

Emphasis was placed upon the reactions to persistent low-grade stresses and strains which are a part of "every day" living and which constitute the core of the bedside problem rather than upon the

well-known responses to major life crises. These studies have revealed the following:

1. Dyspnea associated with inefficient pulmonary ventilation may occur in response to stress-producing life situations in association with anxiety, anger, guilt, rage, frustration, and tension.

2. Palpitation associated with increased stroke volume may occur under similar circumstances.

3. Heart pain in the presence of anatomical narrowing of the coronary arteries may result from increased work of the heart attendant upon prolonged elevation of the blood pressure and cardiac output in association with rage, resentment, anxiety, fear, and tension.

4. Heart pain in the presence of anatomical narrowing of the arteries may result from a fall in the cardiac output and coronary blood flow in association with desperation and defeat.

5. Giddiness and faintness may result from cerebral anoxia attendant upon diminished venous return to the heart. Also, giddiness and faintness may result from hyperventilation, which is followed by cerebral vasoconstriction, impaired dissociation of oxyhemoglobin and cerebral anoxia. Both types of cerebral anoxia occur in response to stress-producing life situations in association with feelings of exhaustion, anxiety, fear, and during the early part of convalescence.

6. Fatigue as experienced by patients is a complex state dependent upon emotional attitude, the absence of a dominant motivation and the presence of a stress-producing life situation with accompanying inefficiency of cadiovascular and respiratory function.

7. Individuals differ as regards the intensity and duration of the cardiovascular and respiratory responses to life situations. The fact that a single subject tends to react under different circumstances in many different ways suggests that the individual is manifesting a variety of ways of dealing with his environment as regards his cardiovascular and respiratory functions.

8. These results indicate that, in a setting of adverse life circumstances and associated emotional reactions, performance in terms of respiration and work of the heart is costly. This high cost may manifest itself in cardiovascular symptoms which are not dependent alone upon gross structural heart disorder. This uneconomical performance may also manifest itself in impaired total efficiency of the individual.

The authors are grateful to Miss Helen Goodell for valuable assistance in all phases of this work.

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SUMMARY OF DISCUSSION BY THE CHAIRMAN, DR. EDWARD WEISS

We had planned this meeting of the Committee on Cardiovascular Diseases of the American Society for Research in Psychosomatic Problems to discuss "Fundamental Problems in the Psychosomatic Approach to Cardiovascular Disease."

Therefore this paper by Dr. Harold Wolff and Dr. George A. Wolf, Jr., is particularly appropriate for our purposes. It represents a day-to-day study of normal individuals and patients with cardiovascular disease and shows that when an individual is burdened by emotional stress his cardiovascular system over-reacts to a standard exercise test as determined by certain cardiovascular and respiratory measurements. By discussing with the individual at the time the measurements were made the important aspects of their day's work, the dominant mood and preoccupations, and any dreams that they could remember, an effort was made to see if a relationship exists between bodily reactions and concurrent feelings.

Important points in discussion concerned the emotionally conditioned patient (Hoskins); the attitude of the patient toward the test procedure and how that may influence results; and the question of a chain reaction regarding emotions and their physiological responses (Fremont-Smith)—what might be referred to as the vicious circle created by anxiety.

Much of the discussion had to do with the question of conscious feelings and emotions (affects) of which the patient was unaware. Many of the group felt that unconscious factors essential to an understanding of the problem were not sufficiently revealed by the psychological technics employed in the study. Others (Saul) suggested that the important point of the study was the demonstration of this particular biological reaction with an indication of the main psychological forces at work. A point was raised regarding similar physiological responses to different affective states (Katz). A suggestion was made (Steele) that group study was important in this kind of investigation and there were many who felt that in this way studies of the unconscious mental life could be correlated with physiological responses. Hypnosis was suggested as a psychological technic for such studies (Fremont-Smith).

Differences in terminology in two universes of discourse (Hoskins) were recognized as one of the difficulties in this kind of an investigation, and trying to apply the same measurements to different phenomena (Cohn) was mentioned as one of the stumbling blocks to team investigation.

The chairman spoke in favor of group study and said that we were not so much interested in proving psychogenesis as we were in simply studying a problem by means of the psychosomatic approach, which means not to study the soma less but only to study the psyche more, in other words, careful combined studies by physiological methods and psychological technics. Reliable methods are available in both fields of investigation.

We hope that this excellent study will inspire others to make further investigations and to report them at future meetings of this group.

PSYCHOSOMATIC RESEARCH FUNDS AVAILABLE

The Psychosomatic Research Fund of the National Committee for Mental Hygiene announces that funds are available for projects dealing with the psychosomatic study of cardiovascular disease, including essential hypertension.

Communications should be addressed to:

Dr. Edward Weiss, Director
269 South 19th Street
Philadelphia 3, Pa.